Active Project (2015 - 2018)

Bulk Metallic Glass Gears (BMGG) Project

Game Changing Development Program | Space Technology Mission Directorate (STMD)

ANTICIPATED BENEFITS

To NASA funded missions:

The most apparent benefits of this technology are for future NASA missions to cold environments such as asteroids, Europa, Mars, and the Moon. Mars Sample Return is a potential beneficiary of dry and non-lubricated cryogenic gearboxes which can significantly alleviate power constraints while also reducing mass to increase the science return.

To NASA unfunded & planned missions:

The most apparent benefits of this technology are for future NASA missions to cold environments such as asteroids, Mars, and the Moon. Mars Sample Return is a potential beneficiary of dry lubricated cryogenic gearboxes which can significantly alleviate power constraints while also reducing mass to increase the science return.

To other government agencies:

The alloys developed for dry lubricated cryogenic gearboxes have shown exceptional wear resistance. Unlike traditional crystalline metal alloys, these alloys can be processed by molding which might present an overall lower cost alternative to traditionally manufactured gears and gearbox components while offering the same performance benefits.

To the commercial space industry:

Cryogenic gearboxes are necessary for actuators in cold environments. Dry lubricated cryogenic gearbox which do not require heaters can be enabling for proposed private asteroid mining ventures by allowing more power to be allocated to mining operations while reducing the mass and system complexity of the actuators. Commercial Mars missions which have surface operations would also benefit from the same power trades; allowing more power to be used for operational activities rather than heating the gearboxes of mechanisms for the cold environment.

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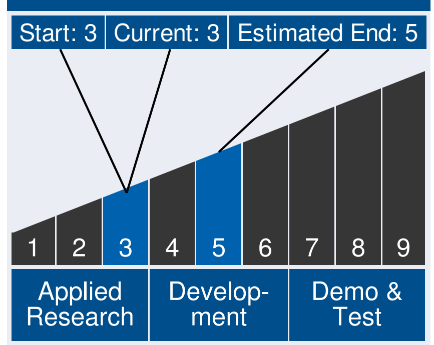
Technology Maturity



Management Team

Program Executive:

- Lanetra Tate

Program Manager:

- Mary Wusk

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To the nation:

In addition to the above, the new BMG alloys developed under this element enable a new set of applications for BMG alloys not previously achievable with current commercially available BMG alloys. These new alloys may open the door to the commercialization of manufactured goods and products not yet imagined.

DETAILED DESCRIPTION

More science can be accomplished on icy body missions, like those to Europa (~90 Kelvin surface temperature), if spacecraft mechanisms can operate without power consuming heaters. NASA's newly invented bulk metallic glass (BMG) alloys are promising for these heater-less mechanisms. We are developing and testing unheated planetary and strain-wave gearboxes, made from these new materials, to enable extreme cold environment mechanisms, reduce power consumption by up to 950 W-h/day for an MSL type rover, save ~7 kg in ancillary electronics mass, and increase science return.

Management Team *(cont.)*

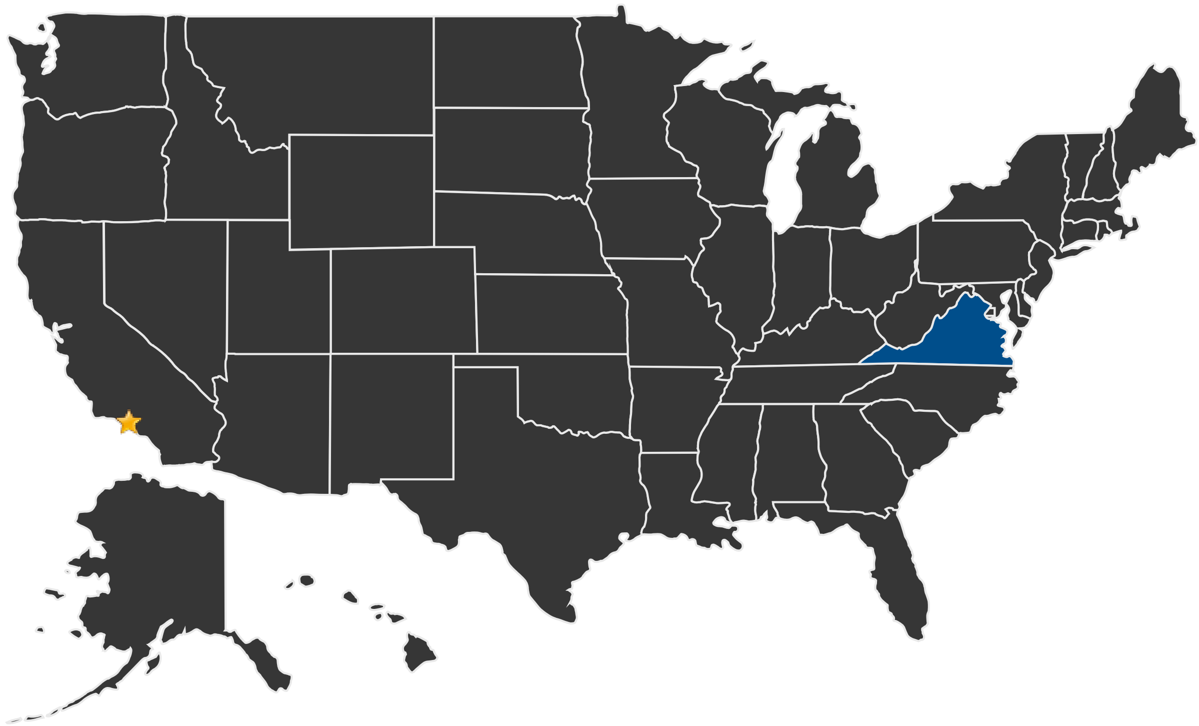
Project Manager:
- Robert Dillon

Principal Investigator:
- Lanetra Tate

Technology Areas

Primary Technology Area:
Materials, Structures, Mechanical Systems and Manufacturing (TA 12)
└─ Manufacturing (TA 12.4)
  └─ Manufacturing Processes (TA 12.4.1)
    └─ Innovative Metallic Process (TA 12.4.1.1)
    └─ Innovative Metallic Process (TA 12.4.1.1)

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Jet Propulsion Laboratory

Other Organizations Performing Work:

- Materion
- Visser Precision Cast

DETAILS FOR TECHNOLOGY 1

Technology Title

Advanced Manufacturing Technologies: Bulk Metallic Glass

Technology Description

This technology is categorized as a hardware assembly for unmanned spaceflight

The phrase “bulk metallic glass” is often used interchangeably with the phrase “amorphous metal.”

Both of these phrases are used to describe a class of materials which consist of metallic atoms which have a disordered arrangement. The phrase “amorphous metal” came first as it accurately described the first thin ribbons and wire composed of a disordered arrangement of disordered atoms. When thicker, larger, bulkier forms could be made amorphous the phrase “bulk metallic glass” was introduced.

These metal alloys have material properties which are quite different from their crystalline forms. They exhibit a glass transition temperature which makes them moldable (like plastic). They have higher strength, are harder and less stiff. They have lower fracture toughness, but can be improved by making a composite form consisting of a ductile, crystalline secondary phase dispersed in the amorphous matrix. There are commercially available alloys but they have been design primarily for use in consumer products like cell phone and watch cases. Industry is not producing new alloys for NASA applications, however industry has the capability and capacity to produce new alloys for NASA applications as these applications are demonstrated and matured.

Thus, NASA has developed new bulk metallic glass (BMG) and BMG composite alloys specifically for applications where commercial industry has not developed suitable alloys. These new alloys have unique properties (e.g. density, wear resistance, strength, toughness) which enable new products like dry lubricated, cryogenic gearboxes which can improve mission science returns by reducing size, weight, or power.

Capabilities Provided

A new NASA developed BMG alloy can be used to fabricate a dry lubricated gearbox capable of operating through extreme environmental ranges (-130°C to +125°C) without heaters enabling actuators for cold body environments which require reduced spacecraft resources and thus allow increased science returns.

Other new NASA developed BMG and BMG composite alloys can reduce the mass of the current state-of-practice micrometeroid shielding enabling larger shields or additional payload mass and lower cost, reduced manufacturing cycle time of high-quality precision optics.

Potential Applications

The new alloys developed for this project enable the design and fabrication of dry lubricated cryogenic gearboxes which will increase the science return of future cold body (e.g. Mars, Lunar, Asteroid) missions by eliminating the power required to heat the wet lubricants in current state-of-the-art gearboxes and the mass of the heating and control equipment and cables.

Other alloys will reduce the mass of the systems used to protect spacecraft from micrometeroids and enable lower cost methods of fabricating high-quality precision optics.